A Global Mobility Scheme for Seamless Multicasting in Proxy Mobile IPv6 Networks

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***Abstract*— Recently, Proxy Mobile IPv6 (PMIPv6) has been drawing attention as a mobility management protocol to effectively use the limited wireless resources. And, there have been some researches to apply PMIPv6 to multicasting, which is core technology of Internet broadcast system. However, PMIPv6 based multicasting cannot support the global mobility directly between different PMIPv6 domains because PMIPv6 is basically designed for local mobility in single PMIPv6 domain. Moreover, PMIPv6 based multicasting causes the disconnection of services because it does not solve problems of packet loss during binding and group joining procedure. In this paper, we propose a global mobility scheme that supports the seamless multicasting service in PMIPv6 networks. The proposed scheme supports the global mobility due to the addition of extra signalling messages between LMAs. Also, it achieves low latency because it performs fast binding and group joining procedure. We present the simulation results which show that the proposed scheme achieves the global mobility with low latency through the NS-2 simulation.**

***Keywords*— Proxy Mobile IPv6, Multicast Mobility, Global Mobility, Seamless Service, Packet loss**

I. Introduction

Recently, communication business is rapidly changed from wired network market to wireless mobile network market. Especially, mobile network environment is gaining attention nowadays, as the portable device such as smart phones and PDAs have been popular recently. In mobile networks, VOD and VoIP have been the main services. But recently, mobile broadcast services like a mobile IPTV are gaining attention in mobile networks.

Mobile IPTV is an IP-based service unlike existing mobile services such as DMB, and it is suitable service to All-IP next generation networks. Mobile IPTV service has weakness in that it has service disconnection problem due to the IP address change while the mobile terminal moves. In order to solve this problem, IETF(Internet Engineering Task Force) proposed Mobile IPv6(MIPv6)[1] to support mobility regardless of IP address change.

MIPv6 is a mobile-controlled mobility management protocol in that mobile node recognizes the handoff by itself and it performs the handoff procedure. But MIPv6 needs to be implemented in the mobile node and it needs many signalling in order to provide the mobility of the mobile devices. These problems make limited link resource overloaded. In order to solve these problems, IETF NETLMM (Network-based Localized Mobility Management) WG (Working Group) proposed Proxy Mobile IPv6 (PMIPv6)[2].

Basically, PMIPv6 is a network-controlled mobility management protocol. PMIPv6 provides mobility to Mobile Node(MN) using two kinds of routers: Mobile Access Gateway(MAG) and Local Mobility Anchor(LMA). MAG performs signalling procedure for MN's movement. LMA performs agent role of MNs. When MN moves, MAG recognizes that MN is moving, and MAG decides if means handover or not. If it is handover, MAG performs handover procedure with LMA. This handover procedure could reduce many signals between MAG and MN. But if PMIPv6 domain gets too wider, routing overhead gets too bigger. So, PMIPv6 assumes that the movements occur only in a PMIPv6 domain[2]. This problem is a critical weakness when adopting the multicast to PMIPv6 networks in order to provide next generation multimedia service. Therefore PMIPv6 needs to provide global mobility as well as local mobility without binding delay and packet loss due to the mobility. In this paper, we propose a seamless multicast scheme which supports global mobility in PMIPv6 networks.

The remainder of the paper is organized as follows. In section 2, as the related works, we will explain about the PMIPv6 and PMIPv6 based global multicast schemes. In section 3, we will explain about the proposed global mobility scheme for seamless multicast service in PMIPv6 networks. Next, in section 4, Simulation results of the proposed scheme will be explained. And then, in section 5, we will conclude this paper.

II. Related Works

A. Proxy Mobile IPv6

PMIPv6 was designed to provide the network-based IP mobility to MN in a topologically localized domain, without

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requiring the MN to participate in any IP mobility related signalling. Existing host based mobility protocols have some weaknesses in that it needs many signalling between MN and network in order to provide the mobility of the MN, and this makes limited link resource overloaded. In order to remedy the weaknesses of MIPv6, PMIPv6 makes the network mainly perform the signalling that is needed to provide the mobility instead of MN. So, MN can be provided the mobility without implementation of the complicated signalling function.

The core functional components used to support mobility in PMIPv6 are the Policy Store (PS), Local Mobility Anchor (LMA), and Mobile Access Gateway (MAG). Figure 1 shows the PMIPv6 network. PS is the entity that manages an MN's authentication and maintains the MN's profile which is a set of parameters configured for a given MN. Meanwhile, MAG performs the role of typical access router that detects the movement of MN and performs the MN's location update by sending mobility related signals to the MN's LMA on behalf of the MN. Also, the MAG ensures that an MN can obtain an address from its Home Network Prefix (HNP) and receive its HNP anywhere within the PMIPv6 domain. As a result, the MN believes it is using the same link obtained with its initial address configuration, even after changing its point of attachment within the network. On the other hand, LMA is similar to HA (Home Agent) in MIPv6, however, it has additional capabilities required to support PMIPv6. The main role of the LMA is to maintain reachability to the MN's address while the MN moves around within the PMIPv6 domain. The LMA includes a Binding Cache Entry (BCE) for each currently registered MN.

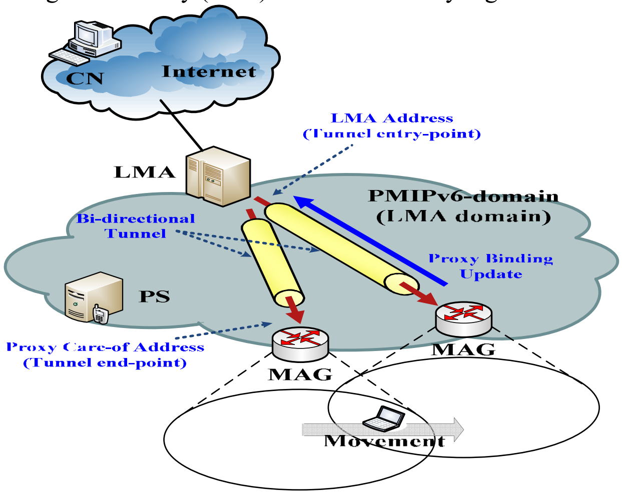

Figure 1. PMIPv6 network

B. Supporting Global Mobility in PMIPv6

As mentioned in introduction, PMIPv6 was designed to provide the network-based IP mobility to MN in a topologically localized domain[2]. However, MN can move out to other domain frequently in real situation. Therefore, the research for global mobility in PMIPv6 is required because there is no protocol definition to support the global mobility. IETF NETLMM WG has researched this problem.

C. Interaction between PMIPv6 and MIPv6

IETF NETLMM WG is standardizing the interaction method between PMIPv6 and MIPv6 to support the global mobility [3]. In this method, a HA is designated in the PMIPv6 domain where MN enters for the first time. Thereafter, LMA in the domain, where MN moves, sends the binding request massage to MN's HA. Figure 2 shows the detail interaction method between PMIPv6 and MIPv6.

At first, MN is connected to MAG1. MAG1 that recognizes the connection of MN by link layer signal, sends PBU(Proxy Binding Update) massage to LMA1 for Binding Update. Then LMA1 completes Binding Update by registering MN's address. This procedure is sufficient for Binding Update in existing PMIPv6 protocol. In the case of PMIP-MIP interaction for global mobility, however, LMA1 has to perform binding Update for MIPv6 with HA. After Binding Update between HA and LMA1, LMA1 need to send PBA massage to MN through MAG1 in order to complete Binding Upadate procedure. Thereafter, MN can be serviced.

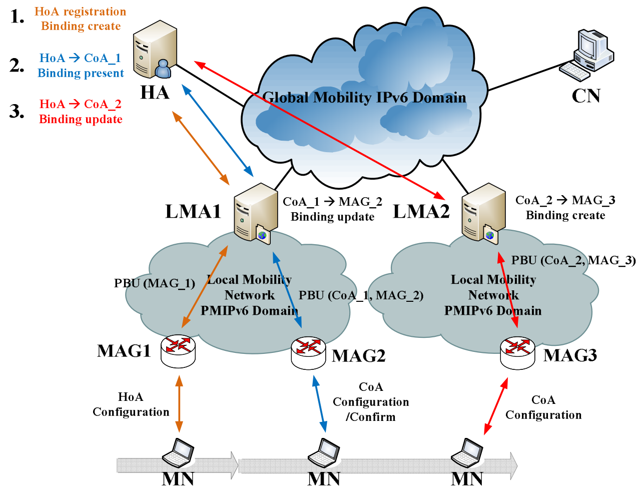

Figure 2. PMIP-MIP Interaction

If MN moves to MAG2, Binding Update is not required because it is not global mobility. But MN's COA(Care-of-Address) has to be changed to MAG2's address. Therefore MAG2 performs Binding Update by sending PBU message to LMA1. Then LMA1 requests Binding Update to HA for COA change.

If MN moves to MAG3, LMA2 requests Binding Update to HA because PMIPv6 domain is changed. HA, which received Binding Update, recognizes that the path to MN was changed. Also it recognizes that COA was changed to MAG3's address. HA redirects the packets destined to MN to new domain. Therefore, MN can be serviced even in case of global mobility without performing any signalling according to MN's movement.

D. Definition of new agent

PMIP-MIP interaction is a global mobility method proposed by IETF NETLMM WG, in which PMIPv6 is combined with MIPv6 signalling.

This method has a problem in that unnecessary delay is occurred by additional signals between LMA and HA even though the advantage of PMIPv6 protocol is maintained because MN does not participate to the binding update procedure. Therefore new method called I-PMIP that add the new agent function to router, was proposed for solving unnecessary delay problem[4]. I-PMIP provides the global mobility by giving the role of HA to the first LMA connected for the first time instead of using the separate HA[4].

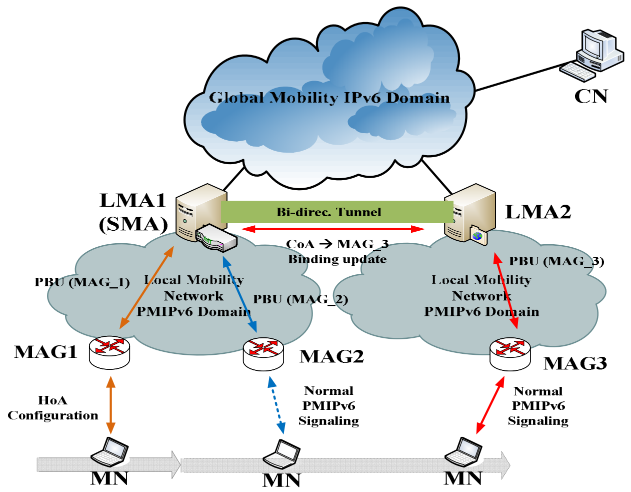

Figure 3. I-PMIP operation

Figure 3 shows the I-PMIP operation. When MN is connected to first LMA, MN receive the service according to PMIPv6 protocol. As shown in figure 3, the location of MN is registered using PMIPv6 signalling messages when a MN is connected to MAG1. Also, the mobility is supported using PMIPv6 signalling messages when MN moves to MAG2. On the other hand, LMA2 requests the binding of MN to LMA1, when MN moves continuously and finally connects to MAG3. This is the core aspect of I-PMIP operation. The first LMA, to which MN is connected for the first time, is called SMA (Session Mobility Anchor) and it provides seamless session to MN even in the case of global mobility..

The first LMA, to which MN is connected for the first time, carries the role of SMA that is similar to HA of MIPv6. Therefore, all packets destined to MN from outside pass through SMA. And, LMA of new PMIPv6 domain requests the binding to this SMA when MN moves away from PMIPv6 domain where SMA resides. After the binding, the bi-directional tunnel is established between SMA and new LMA. Thereafter, all packets destined to MN are transmitted to new LMA through bi-directional tunnel. If MN moves continuously and is connected to LMA of another PMIPv6 domain, bi-directional tunnel is established again.

E. Problems of PMIP-MIP Interaction and I-PMIP

PMIP-MIP Interaction adds the MIPv6 signalling to PMIPv6 signals to provide the global mobility. But adding MIPv6 signal occur unnecessary delay because of binding between LMA and HA. This unnecessary delay causes the problem when PMIP-MIP Interaction is applied to multicasting. When a MN receiving multicast service, is connected to LMA of new PMIPv6 domain but LMA is not a member of multicast group, group joining procedure is occurred. In this case, new LMA requests the binding to HA, and group joining procedure is performed in turn. This leads to the delay of group joining and service disconnection because MN is not able to receive any packet before group joining procedure is completed.

In contrast to PMIP-MIP interaction, I-PMIP does not incur unnecessary delay because it does not require signalling with HA. But, I-PMIP causes the delay if global mobility occurs frequently because the continued bindings to SMA are required. Also, it does not solve the service disconnection problem caused by group joining operation after the binding, because it still needs the binding for global mobility, it reduces the unnecessary signalling with HA by using SMA though.

In this paper, we propose an effective global mobility scheme, which performs the fast binding and group joining procedure, without binding to HA or new agent. Also, the proposed scheme does not incur any packet loss.

III. Proposed Scheme for Global Mobility and Seamless Multicast in PMIP

A. LMA option massage for global mobility

In this section, we explain newly added massage for supporting global mobility without HA and new agent. Using this added massage, each LMA identifies each other without HA and new agent.

<table>
<tr><td>Type</td><td>Length</td><td>Dist.</td><td>Pref.</td><td>r</td><td>Reserved</td></tr>
<tr><td colspan="6">Valid lifetime</td></tr>
<tr><td colspan="6">LMA's Global Address (128 bits)</td></tr>
</table>

Figure 4. LMA option massage format

A router sends RA(Router Advertisement) massage to all other routers for sharing its information. In the newly added massage shown in Figure 4, a LMA's global address option is added. Using this option, LMA configures the LMA entries of other LMA's global addresses in the same manner as their own MAG entry. LMA's global addresses are selectively stored as LMA entry by configuring based on Hop Count according to the distance field in the massage format because the distant LMA's global addresses does not need to be stored. Using this massage, LMAs are able to share each address and inform MN's movement.

B. global mobility for Seamless multicast service

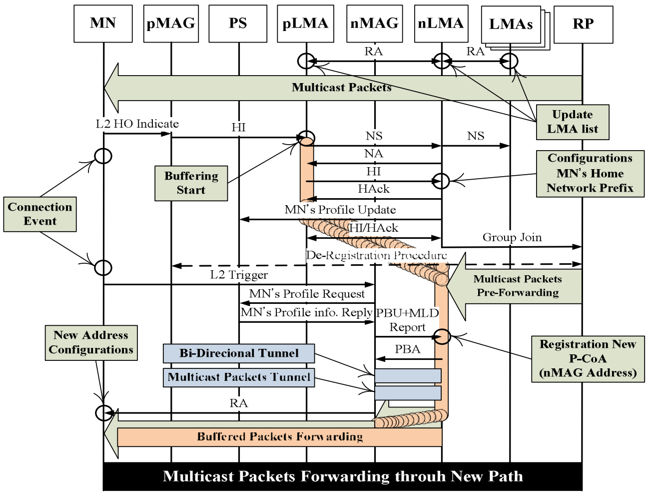

Figure 5. Seamless multicast for global mobility

Figure 5 shows the sequence diagram of global mobility for seamless multicast service. MN first joins to MAG, then its LMA(Previous LMA, p-LMA) provides multicast service to MN via MAG. It assumes LMAs have LMA entry by using new option massage in RA.

When MN moves away from p-MAG to other domain, it performs Figure 5 procedure.

MN recognizes decreasing signal strength from current AP. MN informs handover to its p-MAG via AP. Then p-MAG sends HI(Handover Initiate) massage to p-LMA about MN's handover. This This HI massage includes n-MAG's address as MN's new MAG. A p-LMA checks its own MAG entry whether n-MAG's address is included same domain. If n-MAG's address is not same domain, p-LMA pretends MN's global mobility. Then p-LMA sends NS(Neighbor Solicitation) massage to LMAs that it is included a list of LMA entry. And LMAs that received NS from p-LMA, check each own LMA entries. If one of LMAs discovers n-MAG's address from its own MAG entry, it sends NA(Neighbor Advertisement) massage to p-LMA. Then p-LMA knows MN moves which LMA. And p-LMA sends HI massage to n-LMA for fast handover procedure. In this HI massage, includes MN's ID and multicast information. After receiving HI massage from p-LMA, n-LMA sends HACK(Handover Acknowledgement) and pretends MN's handover.

On the other hand, p-LMA starts buffering multicast data that will forward to MN, when receive HI massage from p-MAG.

It is for seamless multicast service without data loss. P-LMA continues buffering until n-LMA send Hack massage to p-LMA. If p-LMA receives Hack massage, p-LMA sends buffered data to n-LMA.

During buffered data is transmitted to n-LMA, n-LMA updates newly configured MN's information to PS(Policy Store) server. After updating, n-LMA informs that update procedure is completed to p-LMA by HI massage. After that, n-LMA performs group rejoining procedure. Then n-LMA receives multicast data from source. And n-LMA also buffered data from p-LMA sending.

When MN handovers to n-MAG, n-MAG accesses to PS server and request MN's information. After that, n-MAG sends PBU massage to n-LMA for MN's binding update. At this time, n-MAG sends MLD(Multicast Listener Discovery) report massage[5](n-MAG could know MN's multicast information through PS server) to n-LMA at same time. After receiving PBU and MLD massages, n-LMA could know MN is joined its own domain then send PBA massage to n-MAG. And n-LMA starts two channel configuration procedure. One of them is Bi-Directional Tunnel for existed PMIPv6 protocol, another tunnel is Multicast Packet Tunnel as we defined.

After channel configuration procedure, n-LMA sends buffered data to MN through n-MAG. Finally, MN has been moved global mobility and received seamless multicast service.

IV. Simulation

In order to evaluate the performance of proposed handover scheme, we use the NS-2 network simulator[6]. Figure 6 shows the topology used for the simulation. In Figure 6, MN starts moving from AP1 and moves to AP4 with constant velocity, 60m/s. And, MN is connected to MAG through layer 2 handover at intervals of about 60 sec. The parameters used for the simulation are shown in Table 1.

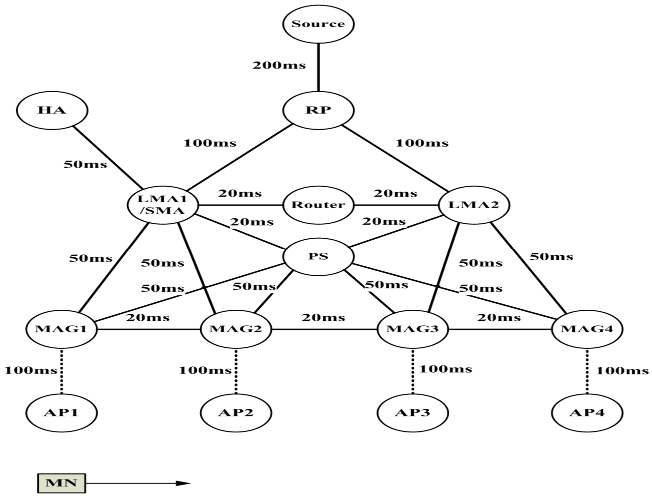

Figure 6. Simulation topology for multicast handover

Table 1. Simulation Parameter

Parameter	Value
Simulation time	300 sec
Distance between MAGs	5km
Link bandwidth	2Mbps
Velocity of MN	60m/s
Bit rate	CBR
Packet size	1Kbyte
Multicast routing protocol	PIM-SM

In order to evaluate that the proposed scheme can provide the seamless multicast service when the global mobility occurs, we measured the UDP Datagram ID, TCP Sequence Number, UDP and TCP Throughput during MN moves from MAG2 to MAG3.

Figure 7 shows the simulation results on UDP datagram ID that MN receives when source node sends the UDP traffic. As shown in Figure 7, PMIP-MIP interaction-based multicast cannot receive the UDP datagram from 120.2 second to 122.5 second. This data loss occurs because of the global binding delay among LMA2, LMA1 and HA after the layer 2 handover between APs and multicast group joining procedure delay. In case of I-PMIP-based multicast, packet loss occurs from 120.2 second to 122.1 second that is shorter than PMIP-MIP interaction-based multicast. This result is caused by the faster binding procedure of I-PMIP because binding is completed at LMA1 unlike PMIP-MIP Interaction. But, as shown in Figure 7, packet loss still occurs from datagram ID 62231 to 62250 in case of I-PMIP.

On the other hand, the proposed scheme can receive the UDP datagram during disconnection period from 120 second to 120.7 second by using buffering. That is, proposed scheme does not experience the packet loss thus provides the seamless service because the datagrams that are generated while MN is moving is saved and retransmitted.

This result affects the UDP throughput as shown in figure 8. The UDP throughput in PMIP-MIP Interaction scheme drops to zero for about 2000ms because of the effect of the global handover, which incurs the binding procedure with HA and group joining procedure after binding. Also, the UDP throughput in I-PMIP-MIP scheme drops to zero for about 1600ms because of the effect of the global handover, which incurs the binding procedure with SMA and group joining procedure after binding. However, the UDP throughput in the proposed scheme drops just for about 790ms because it processes the binding procedure and group joining procedure at the same time. We can also notice that the proposed scheme prevent the throughput from dropping to zero because it performs the buffering.

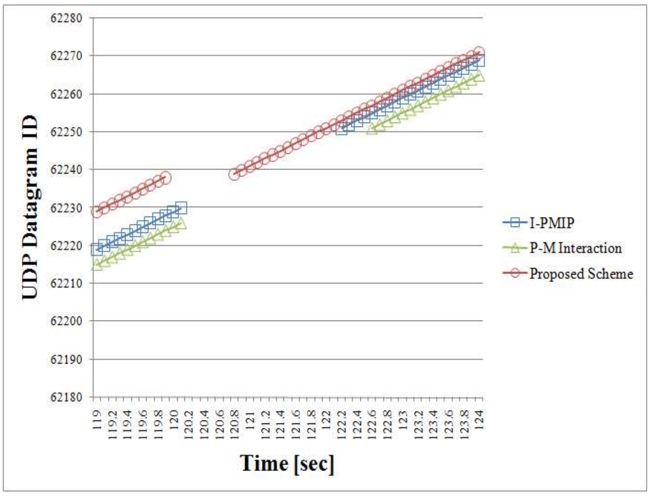

Figure 7. Comparison of UDP datagram ID

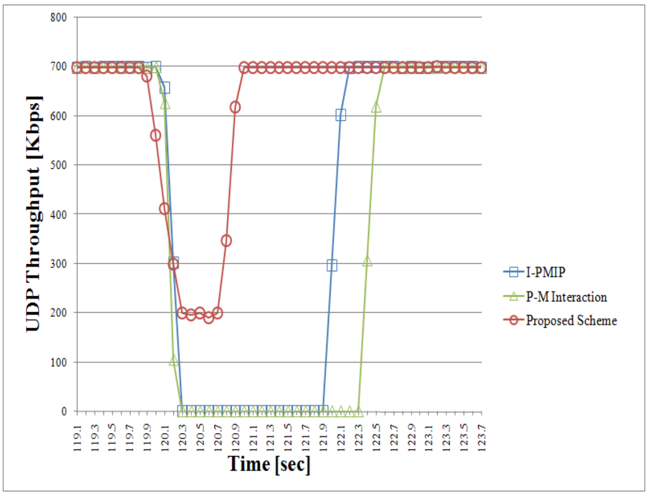

Figure 8. Comparison of UDP Throughput

Figure 9, 10 and 11 shows TCP sequence numbers that MN received. Figure 9 shows received TCP sequence number when P-M Interaction is used. When MN's global mobility is performed, binding delay with HA and group joining delay is occurred during 1990ms that is similar to UDP case. During this delay time, the packets sent by the source cannot be delivered to MN and these undelivered packets are retransmitted by TCP algorithm. These retransmission causes additional delay for packet delivery. Therefore TCP packets experience more delay than UDP packets. Figure 10 shows the received TCP sequence numbers that MN received when I-PMIP is used. I-PMIP also has binding and group joining delay during 1550ms and additional retransmission delay. As shown in Figure 11, however, the proposed low latency global mobility scheme shows relatively short delay due to the fast binding. Also, using buffering scheme, there is no need to retransmit the packets, which leads to seamless multicast service without additional delay.

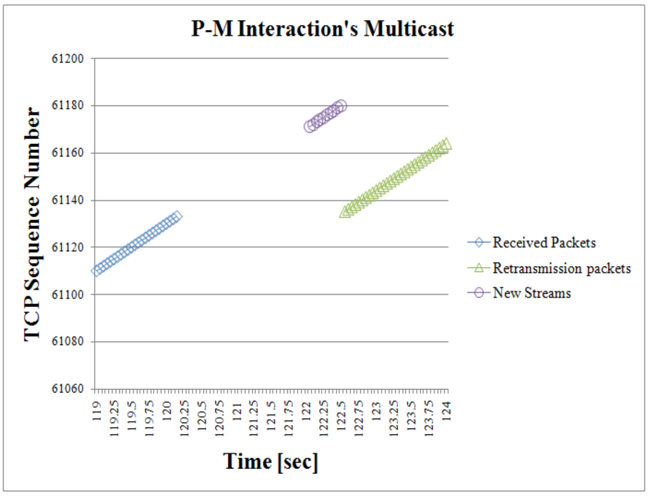

Figure 9. TCP sequence numbers in P-M Interactio

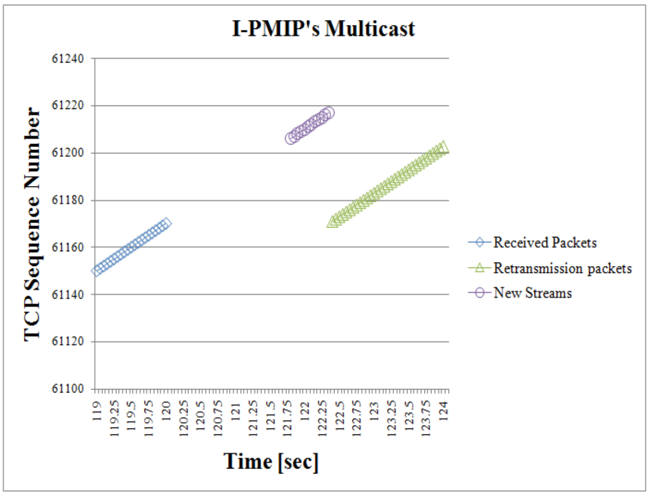

Figure 10. TCP sequence number in I-PMIP

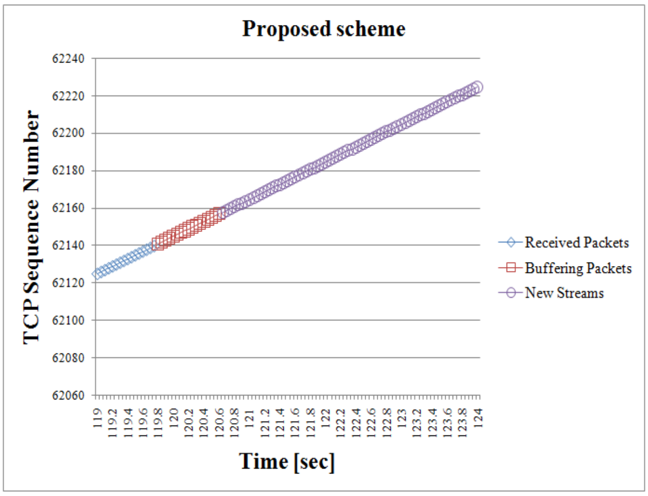

Figure 11. TCP sequence number in proposed Inter mobility scheme

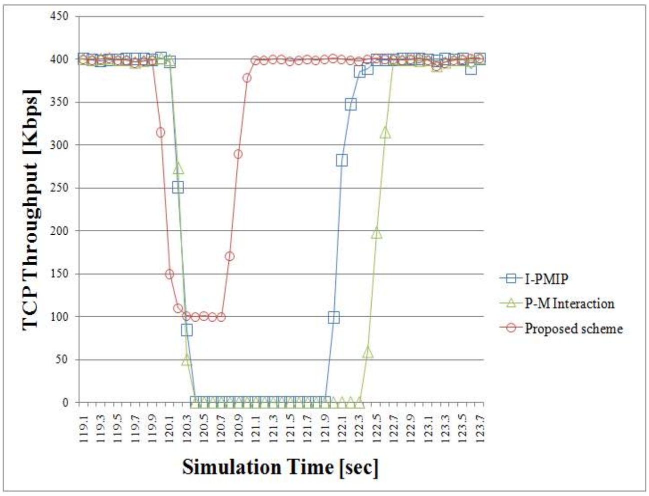

Figure 12. Comparison of TCP Throughput

Figure 12 shows comparison of TCP throughput for three methods. TCP throughput result is very similar to UDP throughput. P-M Interaction is falling down to 0 during 2000ms. And I-PMIP is falling down to 0 during 1600ms. But in proposed scheme, it shows that is not falling down to 0, even if throughput is falling down during 800ms. As a result, these throughput results show the proposed scheme is more effective than other two methods.

V. CONCLUSION

In this paper, we propose a new low latency global mobility scheme which supports seamless multicast service without out-of-sequence problem and packet loss in PMIPv6 networks. Before discussing the proposed scheme, the existing global mobility schemes in PMIPv6 networks are explained. The multicasting based on existing global mobility schemes has the problem in that it causes the unnecessary delay and service disconnection because the global binding to HA or new agent and the group joining procedure has to be occurred in turn. In the proposed scheme, however, the global mobility can be supported without extra global binding because each LMA can identify each other using LMA global address option added to RA massage format. Additionally, LMA could prevent the packet loss using buffering procedure during the global mobility procedure …..

Using the NS-2 simulation, we showed that the proposed scheme reduces the unnecessary delay that the existing global mobility methods have.

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